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INFLUENCE OF VARIOUS STACKING SEQUENCY TO RESONANT FREQUENCY OF CORRESPONDING MODES SHAPES

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ABSTRACT: Fibre-reinforced components of various shapes and different boundary conditions (free, clamped, and hinged) commonly occur in practice. Designers need to be able to predict the stiffness parameters and damping values of such components for conditions such as aeroelasticity, acoustic fatigue, and so on. In this study we investigate the vibration behaviour of square composite plates with different stacking sequences by ESPI. The carbon / epoxy composite plates with stacking sequences $[0]_{6s}$, $[0,90]_{3s}$, $[0/0/0/90/60/90]_{1s}$ composite with carbon fabric are evaluated in this study. Plates were produced by lamination under vacuum foil. The mode shapes of laminate composite plates are influenced by material properties, boundary conditions, geometry, and the lamination arrangement.

KEY WORDS: electronic speckle pattern interferometry (ESPI), resonant frequency, stacking sequence

1. INTRODUCTION

Composite materials have many advantages over monolithic materials, because their mechanical properties can be tailored for a particular application. A popular use of composite materials is in weight saving structures where a combination of high strength continuous fibers, like carbon fiber and Kevlar, and an epoxy substrate produce low density materials. These types of material having continuous fibers produce superior mechanical properties and they can be manufactured either by winding individual fibers around a former, or by laying up layers of pre-preg, i.e. aligned fibers or woven materials embedded in a polymer matrix.

2. EXPERIMENTAL RESULTS

In electronic speckle pattern interferometry (ESPI) a speckle pattern is formed by illuminating the surface of the object to be tested, with laser light. This speckle pattern is imaged onto a CCD array where it is allowed to interfere with a reference wave, which may, or may not, be speckled. The resultant speckle pattern is then transferred to a frame grabber on board a computer where it is saved in memory and displayed. When the object has been deformed, or displaced, the resultant speckle pattern changes due to the change in path difference between the wave front from the surface and the reference wave. This second resultant speckle pattern is transferred to the computer and subtracted from, or added to, the previously stored pattern and the result is rectified. The resulting interferogram is then displayed on the monitor as a pattern of dark and bright fringes, called correlation fringes, as the fringes are produced by correlating the intensities of the resultant speckle patterns taken before and after displacement.

During our experimental investigation we observed four types of samples. Description of investigation samples are in the Table 1. The material properties - the samples was made from epoxy resin MGS L 285 with carbon reinforcement 200g/m^2 by lamination under vacuum foil. The boundaries conditions along the rectangular edge are traction free and the plates is fixed in the centre.

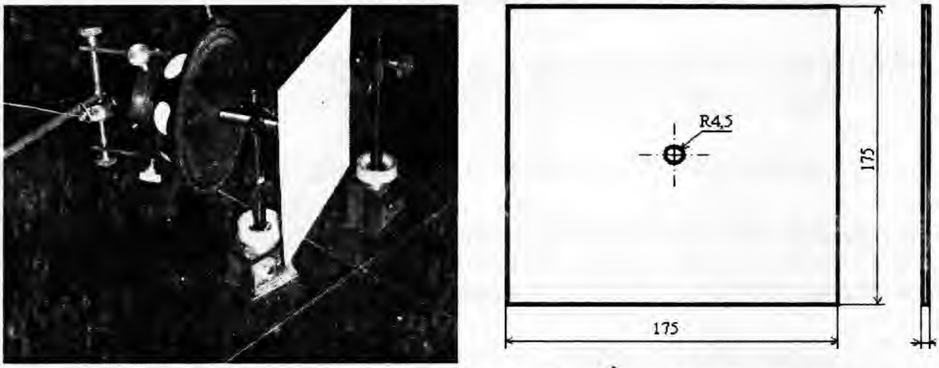

Fig. 1: Fixation and geometric dimensions of investigated laminate plates.

Tab.1: Description of samples –influence of stacking sequences.

Sample	Description of Samples	Weave	Stacking Sequence
1	epoxy/carbon	plain weave	$(0°)_{6s}$
	epoxy/carbon	plain weave	$(0°,90°)_{3s}$
3	epoxy/carbon	plain weave	$(0°, 0°, 0°, 90°, 60°, 90°)_{1s}$
4	epoxy/carbon	plain weave	6 x fabric

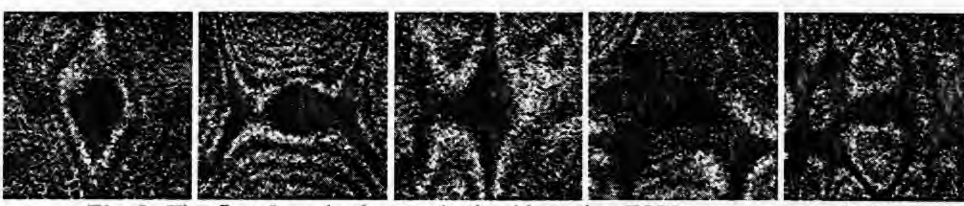

Fig. 2: The first 5 mode shapes obtained by using ESPI system – sample 1.

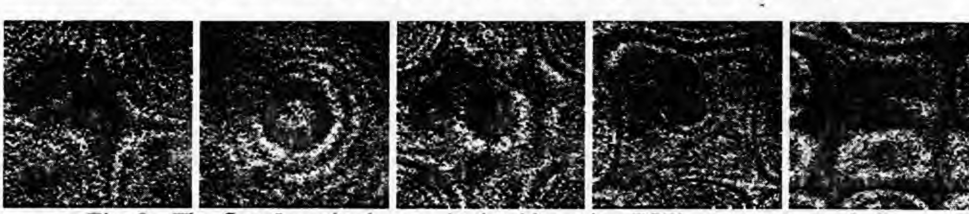

Fig. 3: The first 5 mode shapes obtained by using ESPI system – sample 2.

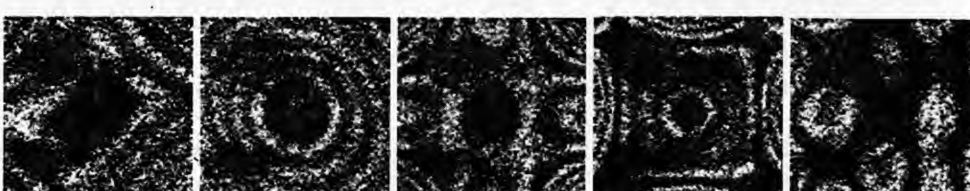

Fig. 4: The first 5 mode shapes obtained by using ESPI system – sample 3.

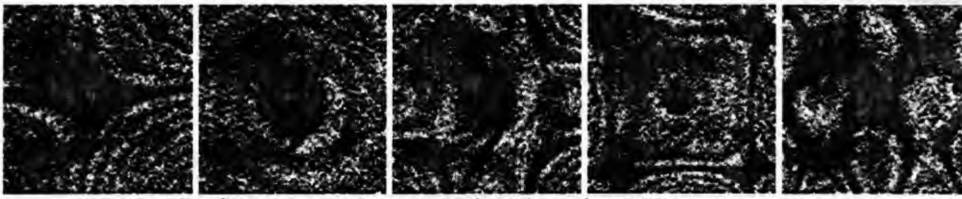

Fig. 5: The first 5 mode shapes obtained by using ESPI system – sample 4.

It can be seen from our experimental results, that samples 2, 3, 4 has the same mode shapes. We can consider the stacking sequence those samples like isotropic materials. On the other hand, samples 1, where the fibres are laying in the one way, we obtained asymmetrical mode shapes. It can be seen in the Figure 2. These mode shapes do not occur by samples 2, 3, 4. The mode shapes obtained by investigation of all four samples are by samples 1 deformed and asymmetrical. Asymmetrical mode shapes by sample 1 is caused that Young's modulus and flexural stiffness are higher in the way of laying fibres like in the perpendicularly way to the way of laying fibres.

3. CONCLUSIONS

Advantages of the ESPI technique include: daylight operation by simply using an interference filter in front of the CCD camera, reduced stability requirements, compact and portable instrumentation, and elimination of photographic processing, full digital data elaboration, no need for high-quality optics and a simplified optical setup, relatively low cost. This paper shows that ESPI method allows getting further information about the frequency dependency of the material properties. The difference between the sample 1 and samples 2, 3, 4 is that the number of carbon fibre laminates in x – direction is different from the y – direction. The mode shapes of laminate composite plates are influenced by material properties, boundary conditions, geometry, and the lamination arrangement.

4. REFERENCES

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